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CONTENTS:

STUDIES ON CICADELLA HIEROGLYPHICA (HOMOPTERA),
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VOL. XIV.] OCTOBER, 1922. [No. 7.

Studies on *Cicadella hieroglyphica* Say (Homoptera, Cicadellidæ.)

BY LUCY M. HACKMAN.

Submitted to the department of entomology and to the graduate faculty of the University of Kansas in partial fulfillment of the requirements for the degree of master of arts, May 15, 1922.

INTRODUCTION.

THE following notes on the life history of *Cicadella hieroglyphica* consist of observations made from specimens in the field and in the laboratory. A growth of young willows along the Kansas river offered a splendid opportunity for the former, for there *Cicadella hieroglyphica* may be found at all seasons in very large numbers. The laboratory observations were made from specimens collected at this place and reared on willow in the laboratory. The most satisfactory results were obtained when the willow was planted in large glass rearing cages. The leaf hoppers could move about at will and were easily observed.

Only a general description of the abdomen is given, for the chief concern of this paper is the genitalia. In tracing out the development of the genitalia in the male and female, the adult genitalia were used as a starting point. To trace the development, the various changes in the genitalia from one instar to another were studied. A study of the ventral surface of the eighth and ninth abdominal segments was sufficient in the case of the female, for all three genital appendages are readily seen from a ventral view. But in the case of the male, where the two pairs of appendages are dorsal in position only, the development of the ventral ones could be traced by such a study. Therefore, particular attention was given to these dorsal or internal genitalia. For this purpose the pygofers were split open

along their dorsal surface, the overlying integument carefully removed, and the genitalia thus exposed. Great modifications in the genitalia occur within a single instar, and an attempt was made to give a rather detailed account of these modifications in the fifth instar.

The writer wishes to express her appreciation to all who have assisted her in this work. Professor Hunter has always been most kind in helping in whatever way possible. Dr. Paul B. Lawson, under whose direction the work was done, has given freely of his time and experience. Kathleen Doering, Philip Readio and Robert Guntert are also deserving of thanks for their interest and assistance.

LIFE HISTORY NOTES.

The following are some of the references to this species:

Tettigonia hieroglyphica Say, Jl. Acad. Nat. Sci. Phila., vi, p. 313, 1831.
Tettigonia hieroglyphica Sig., Ann. Soc. Ent. Fr., ser. 3, iii, p. 805, 1855.
Tettigonia hieroglyphica G. and B., Hemip. Colo., p. 81, 1895.
Tettigonia hieroglyphica Ball, Proc. Ia. Acad. Sci., viii, p. 51, 1901.
Tettigoniella hieroglyphica Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 52, 1914.
Tettigoniella hieroglyphica De L., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.
Cicadella hieroglyphica Van D., Cat. Hemip. N. A., p. 597, 1917.
Cicadella hieroglyphica Ols., Bul. Am. Mus. Nat. Hist., xxxvii, p. 3, 1918.
Cicadella hieroglyphica Lawson, Kan. Univ. Sci. Bul., xii, p. 85, 1920.

DESCRIPTION OF THE SPECIES.

The following is the original description:

Tettigonia hieroglyphica. Dull rufous; head and scutel lineated; hemelytra spotted.

Inhabits Arkansas.

Body obscurely dull rufous; head with a black dot at tip, above literate with black; thorax with a dusky posterior disk; scutel with black more or less curved lines; hemelytra obsoletely spotted, nervures being pale; beneath pale yellowish; pectus with large black spots; feet immaculate; tergum blue-black, edge yellow. Length to tip of hemelytra one-fifth of an inch.

Dr. P. B. Lawson, in his paper on the Cicadellidæ of Kansas, gives the following description of the species:

Form. Rather stout. Length, 6 to 7 mm. Vertex bluntly conical, wider than long. Pronotum nearly twice as wide as long, posterior angles broadly rounded, posterior margin medially emarginated. Elytra broad, but exceeding the abdomen.

Color. Varying from brick red to greenish and slaty blue. Black markings on vertex very strong and distinct, enclosing a light-colored T on basal half. Elytra with pale bands along the costal, claval and sutural margins.

External genitalia. Female: Last ventral segment about as wide as long, lateral margins triangularly produced; pygofers long and narrow, equaling or slightly exceeding ovipositor, bearing a few stout hairs. Male: Last ventral segment less than twice as wide as long; plates long, broad at base, but tapering to long acute apices, margins fringed with short hairs; pygofers long and narrow, equaling or exceeding plates and bearing stout hairs.

Internal male genitalia. Styles short, distinctly bent in at point of attachment to connective by a large, heavily chitinized lobe, then curving outward and tapering gradually to blunt apex, with an outwardly projecting process; connective slender, Y-shaped, stem of Y broadening to broad base; œdagus with pair of short processes extending dorsad from its point of attachment to connective, a long process leaving it dorsally from a point a little past its middle, and a similar longer one leaving it apically, the latter to the left of the former. These two processes are narrow and long, narrowest at the base, and widening to a point shortly before the apex, where they are the widest, the right one wider than the left one, and then tapering to the acute tips. A pair of somewhat narrow triangular chitinous processes extend from the base of the anal tube to the main body of the œdagus.

Hosts. Taken abundantly on willows.

The following variety occurs along with the typical forms:

Cicadella hieroglyphica var. *dolobrata* (Ball). Its bibliography follows:

Tettigonia hieroglyphica var. *dolobrata* Ball, Proc. Ia. Acad. Sci., p. 52, pl. 3, fig. 2, 1901.

Tettigonia hieroglyphica var. *dolobrata* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.

Cicadella hieroglyphica var. *dolobrata* Van D., Cat. Hemip. N. A., p. 597, 1917.

Cicadella hieroglyphica var. *dolobrata* Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

Cicadella hieroglyphica var. *dolobrata* Lawson, Kan. Univ. Sci. Bul., xii, p. 86, 1920.

Doctor Lawson describes this variety as follows:

This is a smaller form than the preceding, appearing more robust. In color it is typically black, retaining a few of the lighter markings of the typical *hieroglyphica* on the front, vertex, pronotum and scutellum, and generally having the claval sutures light.

Genitalia as in the preceding form.

Distribution: Occurs along with the typical form.

Hosts: Willows.

DISTRIBUTION.

Doctor Ball gives the following: "This species, as a whole, is very variable in size and color and recalls *Oncometopia undata* and *lateralis* in their red, green and black forms. The varieties readily fall into two series on structural characters. The first has *hieroglyphica* and *dolobrata* as the extreme in darkening up. These

forms are the only ones found in the Mississippi valley and as far west as central Kansas; they occur also in Texas, Arizona, and Mexico."

Van Duzee reports it from Kansas, New Mexico, Texas, Illinois, Missouri, Iowa, Nebraska, and Arizona.

HOSTS.

Cicadella hieroglyphica may be found on several hosts. Willows (*Salix longifolia and Salix amygdaloides*) are the most common of these, but it is frequently found on poplar (*Populus monilifera*). Occasionally it has been taken on the broad-leafed milkweed (*Asclepias syriaca*) and on giant ragweed (*Ambrosia trifida*).

HIBERNATION.

During the winter the adults hide among the fallen leaves and rubbish on the ground, and appear very sluggish when disturbed. On mild, sunshiny days in January numbers have been observed sunning themselves upon the stems.

SPRING APPEARANCE.

About the middle of February, or when the willows are first beginning to bud, the greater number are to be found on the branches and stems of the willows. They are very gregarious, and often are so clustered together as to completely hide the stem. At this time of year they feed by sucking the sap from the stems, and give off honeydew in such quantities as to cause a noticeable spray. Upon close observation this honeydew is seen to be given off in a rapid succession of droplets from the anal tube. Several specimens were timed in the operation, and from fifteen to thirty drops were given off per minute. This continues for several hours at a time while the insect is feeding. Frequently this operation is accompanied by a spasmodic raising and lowering of the wings, movements of the abdomen, and stroking of the wings and abdomen by the long metathoracic legs.

MATING AND OVIPOSITION.

(Plate XVII, figs. 1-4.)

Early in April mating takes place. By this time the willow buds are beginning to unfold and oviposition begins. Numbers have been watched ovipositing, both in the field and in the laboratory, and the following observations made.

The eggs are inserted in the tissues of the upper surface of the leaf just under the epidermis. In the act of ovipositing the female

braces herself firmly, at times using her beak in addition to her legs for this purpose. In all cases observed she always worked head up. She first unsheaths her ovipositor, punctures the epidermis with its tip, and then inserts it to its full length. The flat surface of the ovipositor now rests parallel to the flat surface of the leaf, with its toothed edge pointing forward. Sawing the ovipositor back and forth she increases the size of the slit until it is large enough for the egg. The egg then passes between the valves of the ovipositor into the chamber prepared for it, and the ovipositor is withdrawn and sheathed. In a very few seconds the process is begun again.

The time taken up in preparing the chamber and depositing the egg varied in several cases observed from two to five minutes, most of which time was spent in preparing the chamber. To cite a characteristic case, the whole operation occupied two and one-half minutes, the two minutes being spent in preparing the chamber and the half minute in placing the egg.

The eggs may be laid singly or side by side in even rows. The largest number found in a single row was twenty-five and the largest number in a single leaf was thirty-five. The eggs in a hundred rows or masses were counted, and the average number per row was found to be seven.

The effect of oviposition on the leaves is noticeable. The greater number of eggs are laid in leaves not fully developed, and the presence of the eggs causes the growing leaf to become distorted and to curl around the eggs. However, in no case observed did oviposition kill the leaf. Eggs have been found in both willow and poplar leaves.

NYMPHS.

(Plate XVI, figs. 1-6.)

Soon after oviposition, nymphs may be found feeding on the leaves. Eggs observed in the laboratory hatched in from eight days to two weeks. During their nymphal life these little leaf hoppers molt five times and become adult in a little over two months, or about the middle of June. By the middle of May the adults of the overwintering generation are all dead. Shortly after becoming adult, the new adults mate and another generation is completed by the end of summer. This generation consists of the overwintering individuals. Nymphs of this generation have been found abundantly on giant ragweed and goldenrod, and in all probability the eggs for this generation are laid in these hosts.

DESCRIPTION OF THE INSTARS.

For the description of the various instars an attempt was made to select an average indivdual. It is possible to separate the males and females of the same instar by an examination of the ventral surface of the eighth and ninth abdominal segments. This is discussed later in greater detail under the development of the genitalia of each sex. Except for this, and a slight difference in size, the female being the larger, the two sexes are practically the same.

Egg.

(Plate XVII, fig. 1.)

Length, 1.25 mm. Greatest width, .41. Subovoid in shape, somewhat pointed at one end; greenish yellow at first; just before hatching deeper yellow with dark eyespots.

First Instar.

(Plate XVI, fig. 1.)

Length, 2.65 mm. Width across eyes, .65 mm. Pale yellowish white, eyes black and prominent; anterior margin of head evenly rounded; two pairs of wing pads present, first pair short, barely covering base of second pair, caudal margin in form of an inverted W, with median projection extending farther caudad than lateral projections, exposed portion of second pair more than twice as long as first pair, caudal margin nearly straight, the segments marked off by light brownish bands.

Second Instar.

(Plate XVI, fig. 2.)

Length, 3.15 mm. Width across eyes, .9 mm. Color same as in first instar; margin of head similar; wing pads have increased in length and width, but relative shape and position are the same; caudal margin of second pair bent slightly cephalad medially.

Third Instar.

(Plate XVI, fig. 3.)

Length, 4.25 mm. Width across eyes, 1 mm. Color and shape of head unchanged; wing pads show decided change in length and width, lateral angles of first pair produced caudad and much longer than median projection; exposed length of second pair but little longer than first pair.

Fourth Instar.

(Plate XVI, fig. 4.)

Length, 5.3 mm. Width across eyes, 1.35 mm. Color and shape of head practically the same as in preceding instars; lateral angles of first pair of wing pads now reach almost to the apex of the second pair; lateral angles of second pair have now extended farther caudad, making median indentation in caudal margin more pronounced; do not extend beyond second segment of abdomen.

Fifth Instar.

(Plate XVI, fig. 5.)

Length, 6.4 mm. Width across eyes, 1.4 mm. Color the same, head becoming slightly more pointed, markings more distinct; lateral angles of first pair of wing pads still further produced and are now about the same length as second pair; lateral angles of second pair also further produced caudad and now extend almost to fourth abdominal segment.

Adults.

(Plate XVI, fig. 6.)

The second generation, or the overwintering one, consists of the typical reddish adults. The sexes can be easily distinguished one from the other by the darker color of the male abdomen as contrasted with the lighter color of the female's. These produce the slaty-gray individuals of the summer generation. The black form, the variety *dolobrata*, is also present at this season. However, only males of this form have been found. They mate with the slaty-gray individuals, which are for the most part females, although males of this type are numerous. Very evidently, the dark forms are dimorphic males of the summer generation. A single dark male was taken April 1 with the overwintering red forms, but whether this is one of the summer forms which has overwintered or one of the wintering generation which differs in color from the rest of the generation has not been determined.

MORPHOLOGICAL STUDIES.

GENERAL DESCRIPTION OF THE ABDOMEN.

(Plate XVIII, figs. 1-3; 6-9.)

The abdomen is joined broadly to the metathorax. It continues at the same width for about two-thirds of its length, and from there tapers to a somewhat pointed apex. In a general cross section it is semicircular in outline. The sternite and the pleurites, ventral in position, form the straight part of the semicircle, while the curved, dorsal tergite forms the circular part. Eleven segments can be accounted for. In the male, six of these are represented by complete sternites, pleurites and tergites, but in the female only five are so represented. In the first two segments only the sterna and terga are present, the pleura being represented by pleural membranes. Segments three to eight in the male and three to seven in the female are typical. The terminal segments in both sexes are modified. These modifications are discussed under the heading "external genitalia" in the description of the species. In addition to what is given there, I should like to add that the ventral valve of the adult is present, but concealed by the last ventral segment.

DEVELOPMENT OF MALE GENITALIA.

(Plate XIX, figs. 2, 4, 6, 8, 10, 12; Plate XX, figs. 1-18.)

The male genitalia, consisting of three pairs of valves arise from a genital area on the ninth abdominal segment. In the first, second and third instars there are two pairs of valves present. These develop in small chitinous pockets, which are attached at the caudal edge of the genital area with their apices directed caudad. The genital area increases slightly in size in each successive instar, as do the pockets. The pockets are placed one upon the other, the ventrally placed pocket producing the plates of the adult and the more dorsal pair the œdagus. The ventral pair is about twice as long as the dorsal. Both taper caudad, and are somewhat rounded at the apex. Each pair is divided into its right and left valve by a chitinous median partition.

In the fourth instar there is, as in the former instars, a noticeable increase in size, both of the genital area and of the ventral and dorsal pockets. In addition to these structures, there is now present a pair of small lateral pockets located at the lateral margin of the genital area, and extending caudad as far as the bases of the dorsal pockets. In these lateral pockets develop the styles of the adult genitalia. In the fifth instar there is no great change in the relative position and shape of the pockets. There is, of course, a natural increase in the size of all three pockets.

In the fifth instar the greatest changes in the developing genital appendages take place. The three pairs of valves may be traced through several distinct phases of development by a study of the soft, white integument which can be drawn from the chitinous pockets. Details of five particular phases might be mentioned. (Plate XX, figs. 6-18.)

The ventral plates which develop in the ventral pockets show very little change throughout the successive phases of this instar.

The styles which develop in the lateral pockets are present in all five phases and show a gradual increase in size through the phases. In the fourth phase they first show their permanent attachment to the ventral plates, which is more apparent in the fifth phase and in the adult. They are attached on their outer edges near the base of the plate.

The developing œdagus or the integument drawn from the dorsal pockets shows the most remarkable alterations. In phase 1 the œdagus consists of two valves placed parallel to the ventral plates.

In phase 1, ventral aspect, the valves placed side by side are comparatively narrow at their bases, widest at a point a little before the middle, and then tapered to somewhat pointed apices. Dorsally they do not appear to extend as far cephalad as they do ventrally, nor are they divided into right and left valves except for a short distance apically, at which point they are widely separated.

In phase 2, viewed ventrally, the two valves have become longer and slightly narrower than in the preceding phase, and instead of their former relationship, side by side, the right valve at the base is now assuming a ventral position with respect to the left valve. Also, the flat surfaces of the valves, instead of being parallel to the ventral plates, are now assuming a perpendicular position. Between the valves, at a point a little beyond the middle, a short, slender finger-like process is visible. Viewed dorsally, this process appears between the two valves at the point of wide separation in phase 1 and projects for a short distance caudad. It is an evagination of the integument of the valves.

In phase 3, ventral aspect, the two valves have continued to increase in length. The right valve is distinctly folded over the left valve at the base. A lateral aspect shows plainly the relative position of the median process and the valves. In phase 3, dorsal aspect, there is little change in the valves except an increase in length. The median process also shows an increase in length and width.

In phase 4, ventral view, the valves again are longer than in the preceding phase, and the median process also shows a distinct increase in length. The folding of the right valve over the left valve is more complete, and the bases of the two valves are farther apart than in the preceding phase, the left valve having moved caudad.

In phase 5 the œdagus appears very similar to the adult œdagus. Here the valves have become very much longer than in phase 4. The median process has increased greatly in length.

During the development of the valves their apices have maintained their relative length in respect to the ventral plates. The increase in length has been taken up by increased dorsal curvature.

For a description of the adult male internal genitalia, reference may be made to the description of the species.

DEVELOPMENT OF THE FEMALE GENITALIA.

Ovipositor of Adult.

(Plate XVIII, figs. 4-6.)

In the female the genitalia also consist of three pairs of appendages. They are the ventral and dorsal pairs, which make up the ovipositor proper, and the lateral pair, within which the ovipositor is folded. The ventral pair arise from the eighth sternum, and the dorsal and lateral pairs arise from the ninth sternum, the dorsal pair from its cephalic margin and the lateral pair from its caudal margin.

The ventral valves arising from the eighth sternum are two long, slender valves, tapering caudad and sharply pointed at the apices. They are ventral in position and inclose the dorsal valves. The ventral and dorsal valves of each side are joined one to the other by a tongue-and-groove arrangement, the tongue being on the dorsal valve and the groove on the ventral.

The dorsal valves are innermost of the three pairs and are dorsal in location. They consist of a narrow, curved, rodlike base, and a broader, flattened apical part which bears teeth along its dorsal edge. The apex is sharply pointed and bears very fine teeth on both dorsal and ventral edges. There are from seventeen to nineteen large teeth on the dorsal edge.

The lateral valves are the outermost of the three and enfold the other two pairs. They are broad, flat, and somewhat concave on their inner surfaces. They are not capable of extension as are the other two pairs, for in addition to being attached basally to the ninth sternum, they are also attached to the pygofers for about one-half their length. Their apical half is free.

Nymphal Genital Appendages.

(Plate XIX, figs. 1, 3, 5, 7, 9, 11.)

In the first and second instars two pairs of very small chitinous pockets may be seen, one projecting caudad from the eighth sternum and the other from the ninth. In the first pair develop the ventral valves of the adult ovipositor, and in the second the dorsal valves. In these two instars the apices of the ventral pockets are at a distance from the bases of the dorsal pockets. The dorsal pockets, extending caudad for about one-third the length of the ninth segment, are also short.

In the third instar the ventral pockets have increased in length and width. They are still short and broad. Their broadly rounded

apices overlap the bases of the dorsal pockets. The narrower, longer dorsal pockets extend caudad for about one-half the length of the ninth segment. In this instar the lateral pockets first appear. They lie laterad of the dorsal pockets, are slightly curved and somewhat narrower and shorter than these.

In the fourth instar the ventral pockets are longer than in the preceding instar, and are now more than two-thirds the length of the dorsal pockets. The ventral, still the longer of the two pairs, are about the same distance from the tip of the ninth segment. They are beginning to be enfolded by the lateral pockets, which have broadened and are now somewhat concave on the inner surface. The lateral pockets are longer than the ventral pockets, but shorter than the dorsal.

In the fifth instar the three pairs of pockets are rather darkly chitinized. The ventral pockets are broad at the base and taper gradually to narrowly rounded apices. They are the shortest of the three pairs, though nearly as long as the dorsal pair. Only the extreme apices of the dorsal pockets are visible, their basal portion being hidden by the broader ventral pockets. They are still longer than the ventral pockets, but are now exceeded in length by the lateral pockets. These are somewhat spoonlike and have more completely enfolded the dorsal pockets.

PLATE XVI.

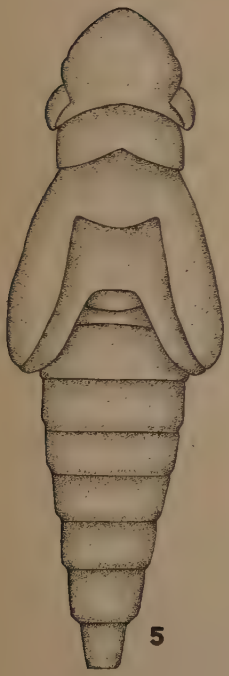
1. First instar.
2. Second instar.
3. Third instar.
4. Fourth instar.
5. Fifth instar.
6. Adult.

PLATE XVI.

2

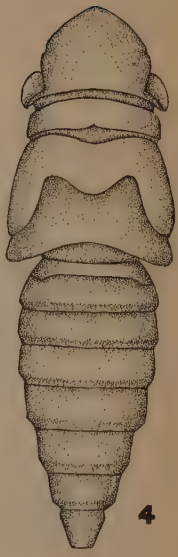
1

3



5

6



4

PLATE XVII.

1. Egg enlarged.
2. Leaf with two egg masses.
3. Leaf showing effect of oviposition.
4. Twig showing effect of oviposition.

PLATE XVII.

PLATE XVIII.

1. Abdomen of adult female.
2. First sternite of female abdomen.
3. Second sternite of female abdomen.
4. Ventral valve of ovipositor attached to eighth sternum.
5. Dorsal valves (upper) and lateral valves (lower), showing attachment to ninth sternum.
6. Terminal segments of female abdomen, showing ovipositor.
7. First sternite of male abdomen.
8. Second sternite of male abdomen.
9. Abdomen of adult male.
10. Cephalic view of main body of œdagus.
11. Caudal view of main body of œdagus.
12. Œdagus, showing attachment of ejaculatory duct.
13. Styles and connective.
14. Ventral valves, dorsal aspect, showing attachment of styles.
15. Male genitalia.

PLATE XVIII.

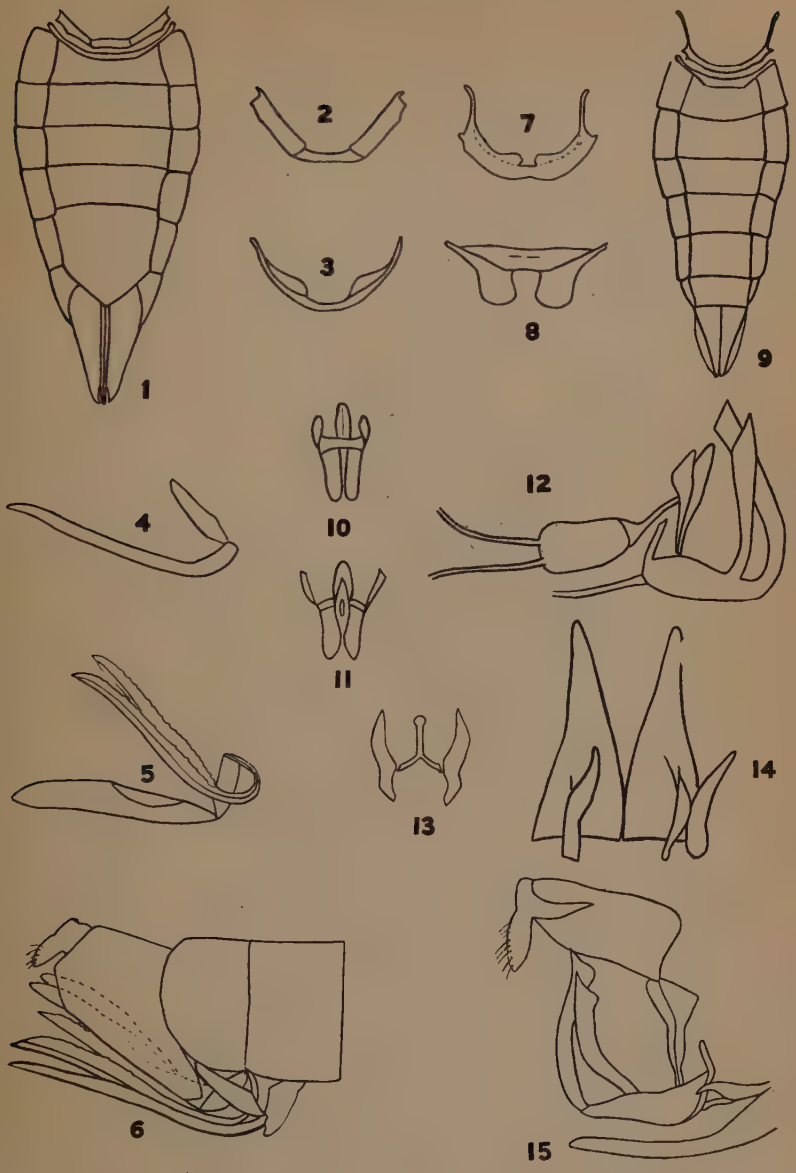


PLATE XIX.

TERMINAL SEGMENTS OF ABDOMEN:

1. Female, first instar.
2. Male, first instar.
3. Female, second instar.
4. Male, second instar.
5. Female, third instar.
6. Male, third instar.
7. Female, fourth instar.
8. Male, fourth instar.
9. Female, fifth instar.
10. Male, fifth instar.
11. Female adult.
12. Male adult.

PLATE XIX.

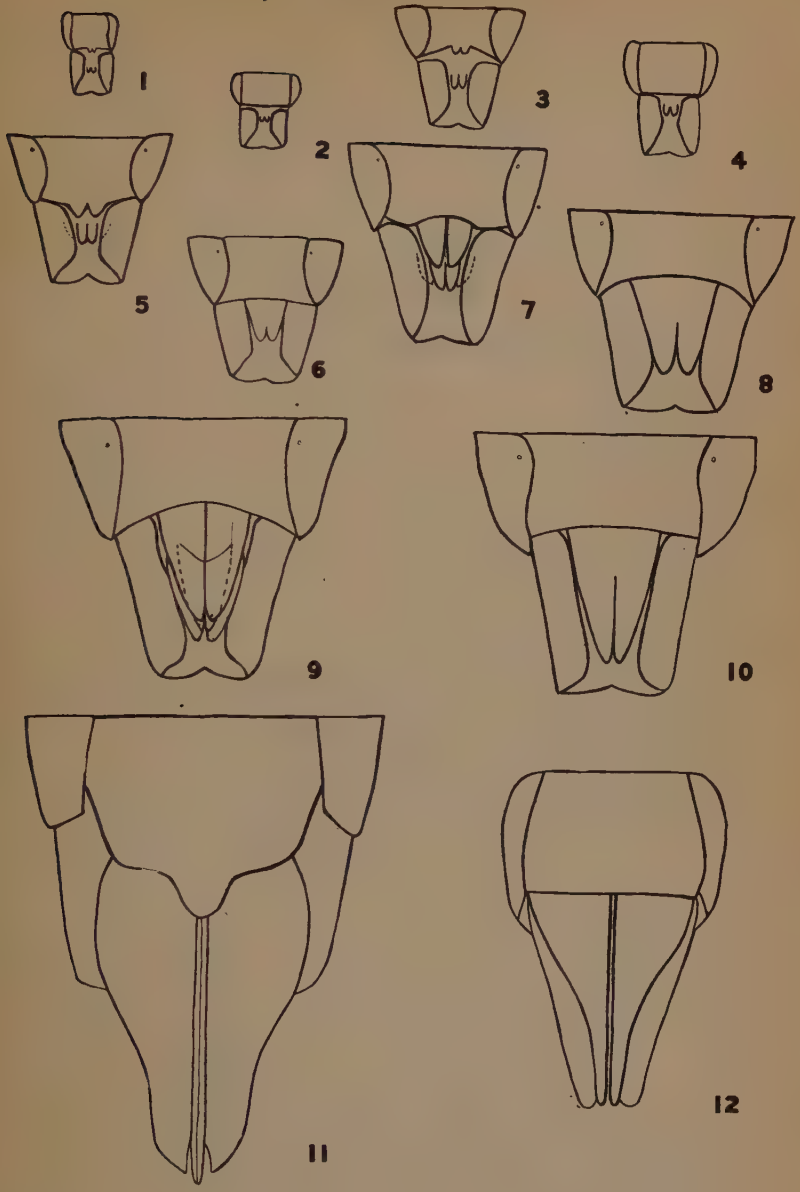


PLATE XX.

DEVELOPMENT OF MALE INTERNAL GENITALIA:

1. First instar.
2. Second instar.
3. Third instar.
4. Fourth instar.
5. Fifth instar.
6. Fifth instar, phase 1, dorsal view.
7. Fifth instar, phase 1, ventral view.
8. Fifth instar, phase 2, dorsal view.
9. Fifth instar, phase 2, ventral view.
10. Fifth instar, phase 3, dorsal view.
11. Fifth instar, phase 3, ventral view.
12. Fifth instar, phase 3, lateral (right) view of œdagus.
13. Fifth instar, phase 3, lateral (left) view of œdagus.
14. Fifth instar, phase 4, ventral view of œdagus.
15. Fifth instar, phase 4, lateral (right) view of œdagus.
16. Fifth instar, phase 4, lateral (left) view of œdagus.
17. Fifth instar, phase 4, lateral (right) view of œdagus.
18. Fifth instar, phase 4, relative position of plates, styles and œdagus.

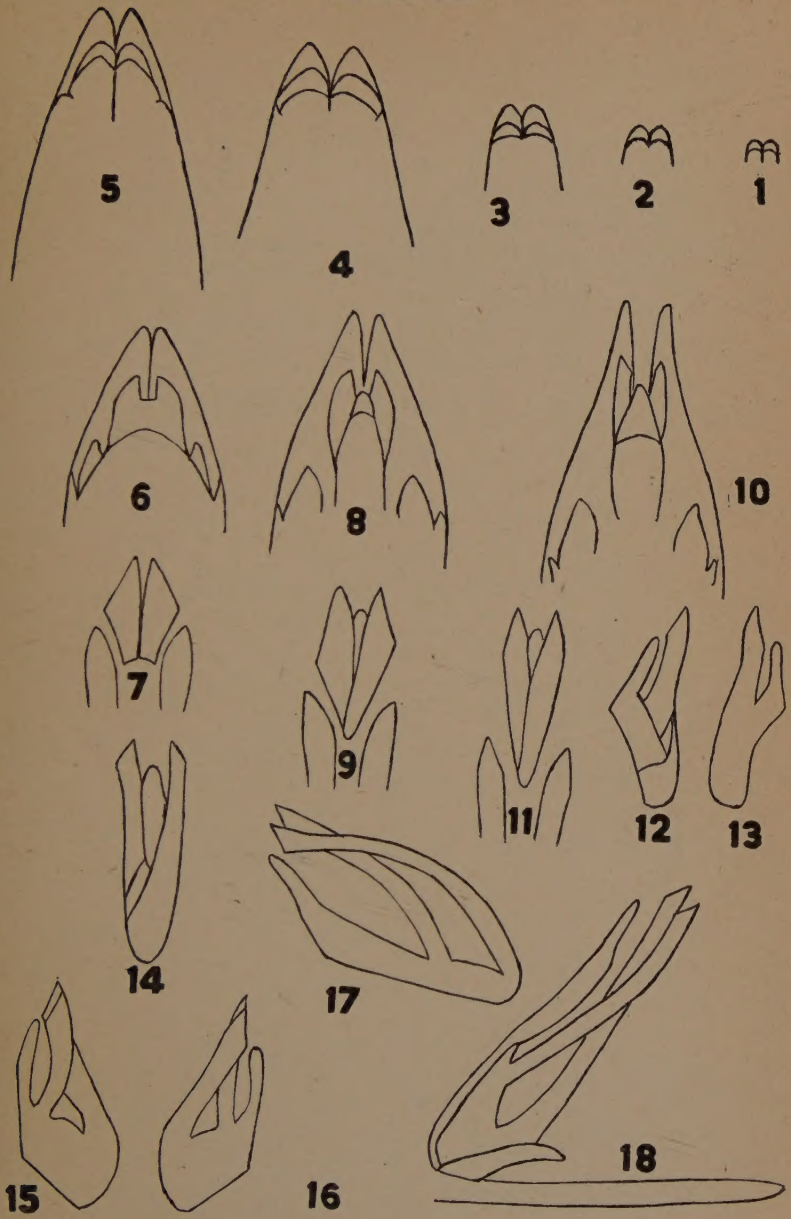



PLATE XX.